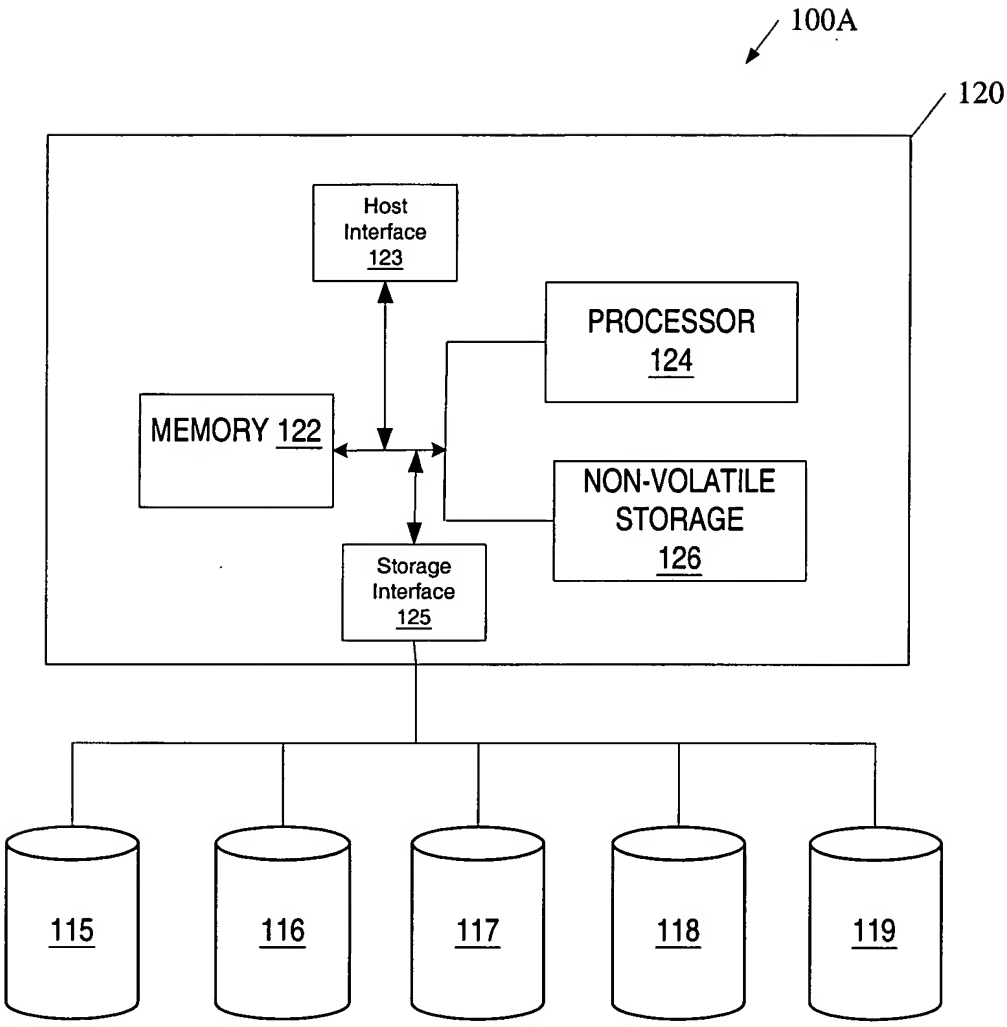
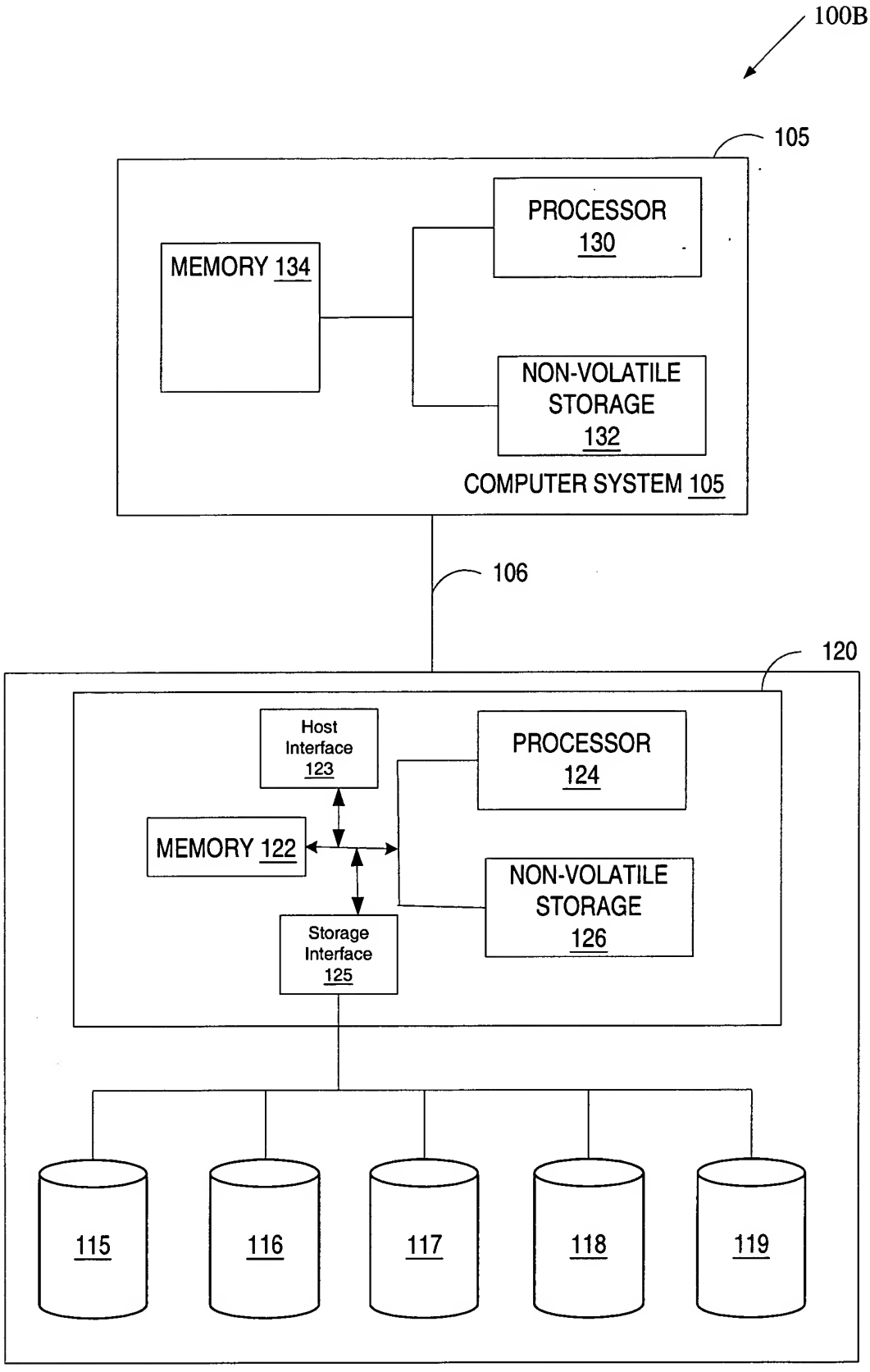

100A
120
Host Interface 123
PROCESSOR 124
MEMORY 122
NON-VOLATILE STORAGE 126
Storage Interface 125
115
116
117
118
119

Figure 1A


100B
105
PROCESSOR
130
MEMORY 134
NON-VOLATILE
STORAGE
132
COMPUTER SYSTEM 105
106
120
Host
Interface
123
PROCESSOR
124
MEMORY 122
NON-VOLATILE
STORAGE
126
Storage
Interface
125
115
116
117
118
119

Figur 1B

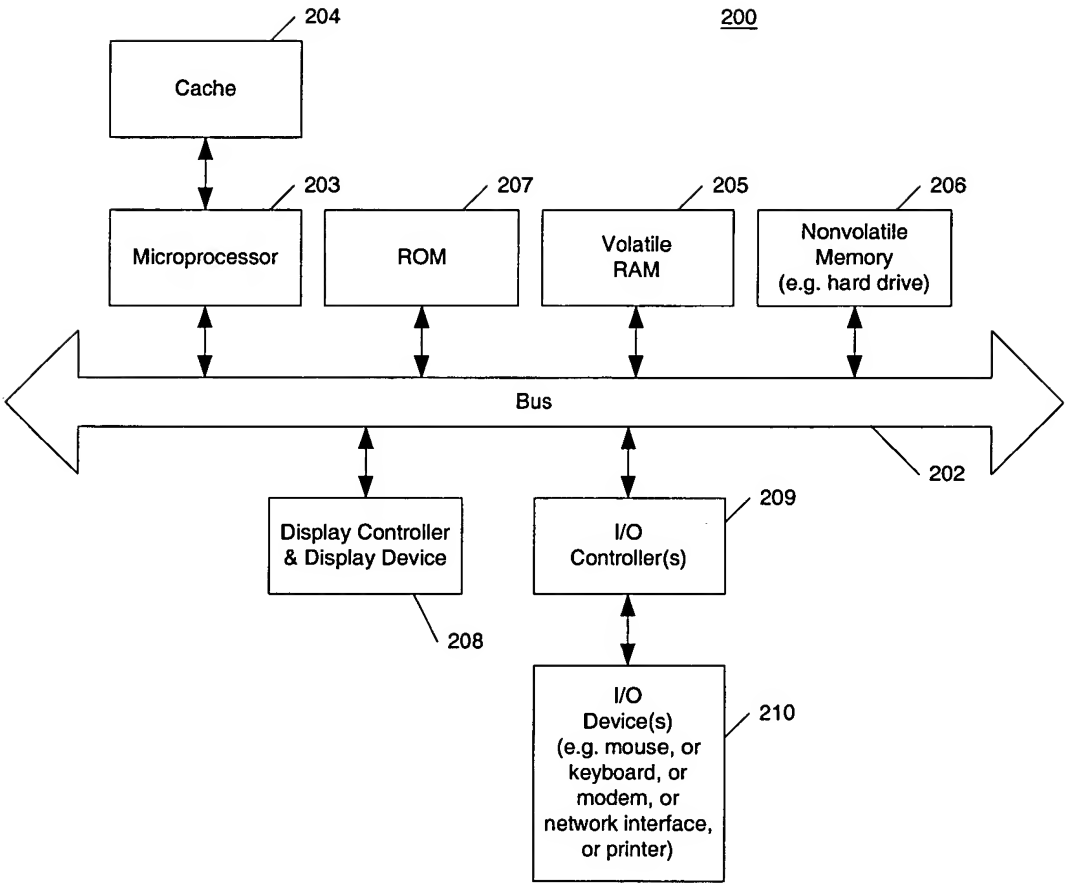

200
204
Cache
203
Microprocessor
207
ROM
205
Volatile
RAM
206
Nonvolatile
Memory
(e.g. hard drive)
Bus
202
Display Controller
& Display Device
208
209
I/O
Controller(s)
I/O
Device(s)
(e.g. mouse, or
keyboard, or
modem, or
network interface,
or printer)
210

Figure 2

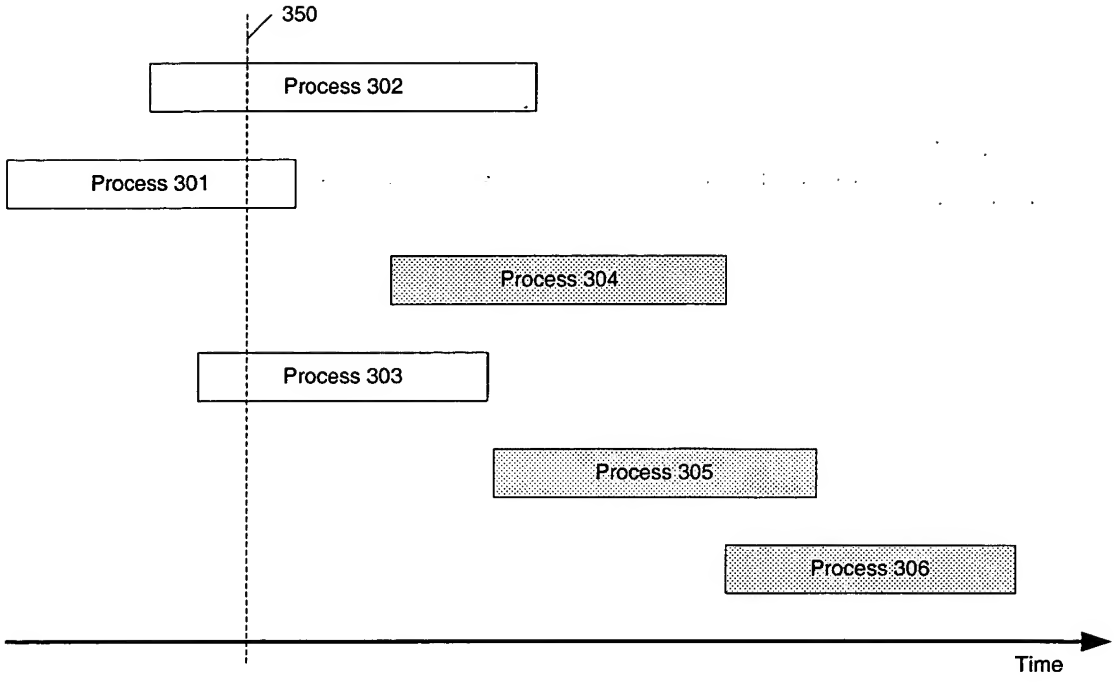
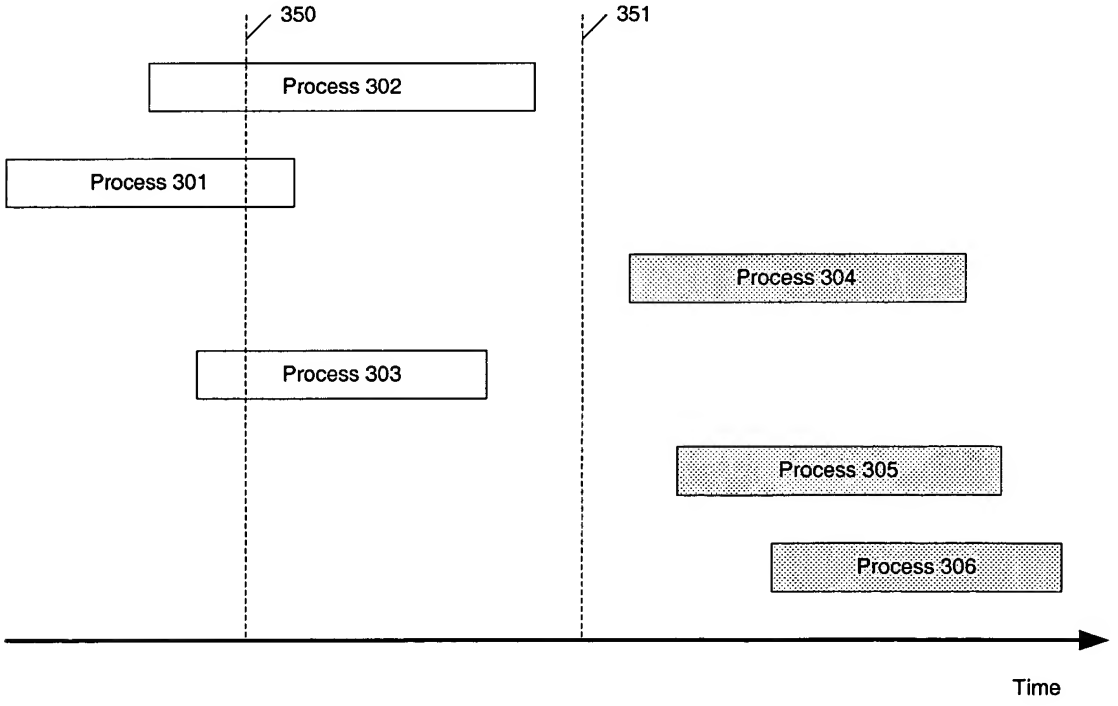


Figure 3A



Figur 3B

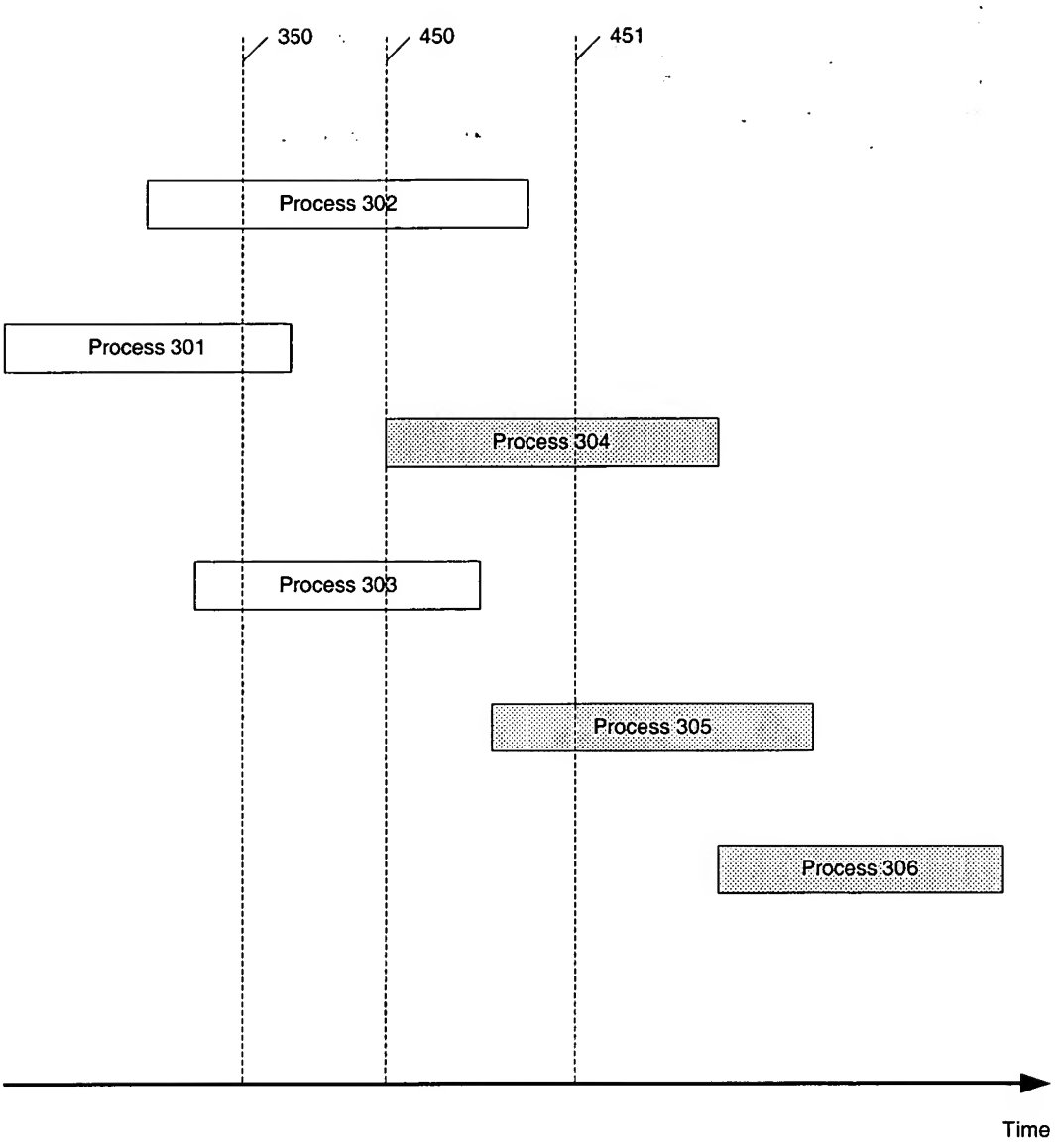

350
450
451
Process 302
Process 301
Process 304
Process 303
Process 305
Process 306
Time

Figure 3C

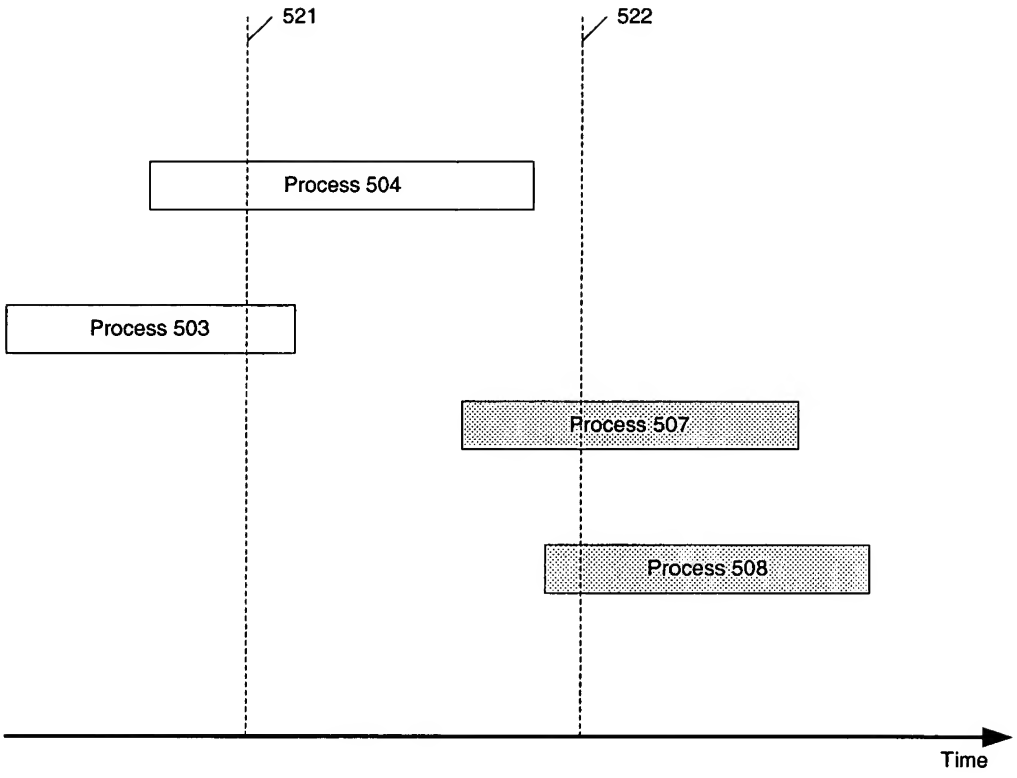

521
522
Process 504
Process 503
Process 507
Process 508
Time

Figure 4

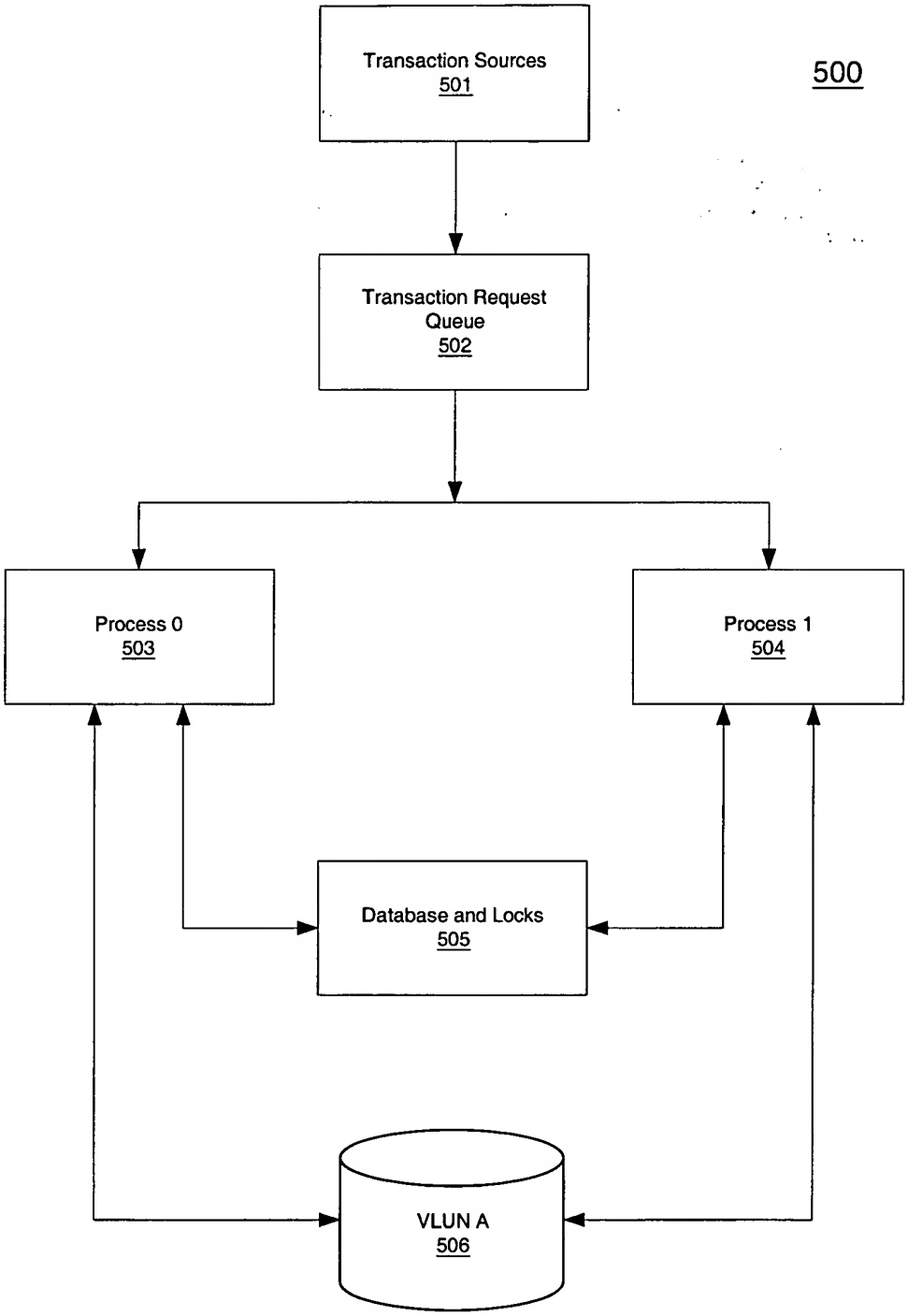
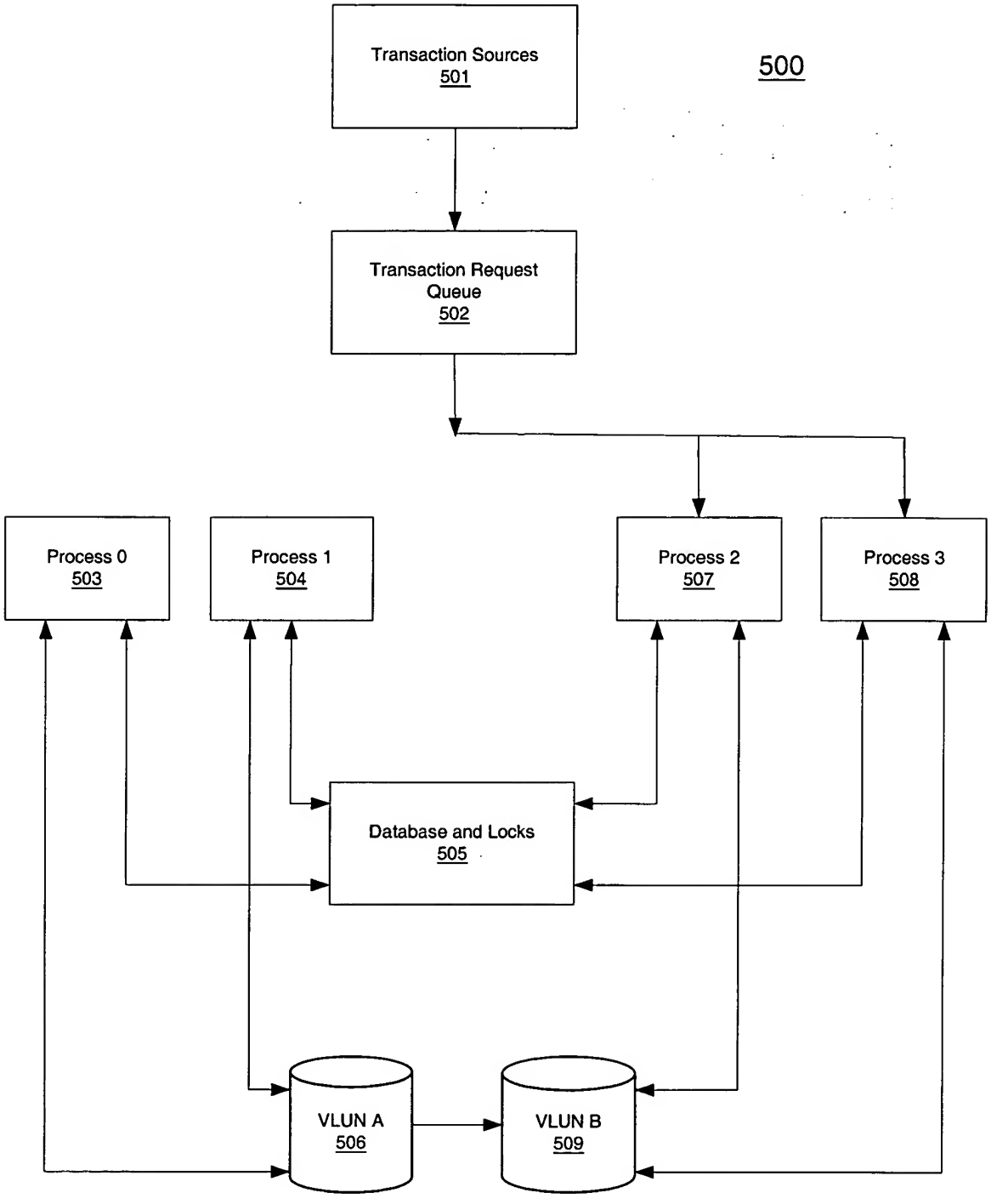
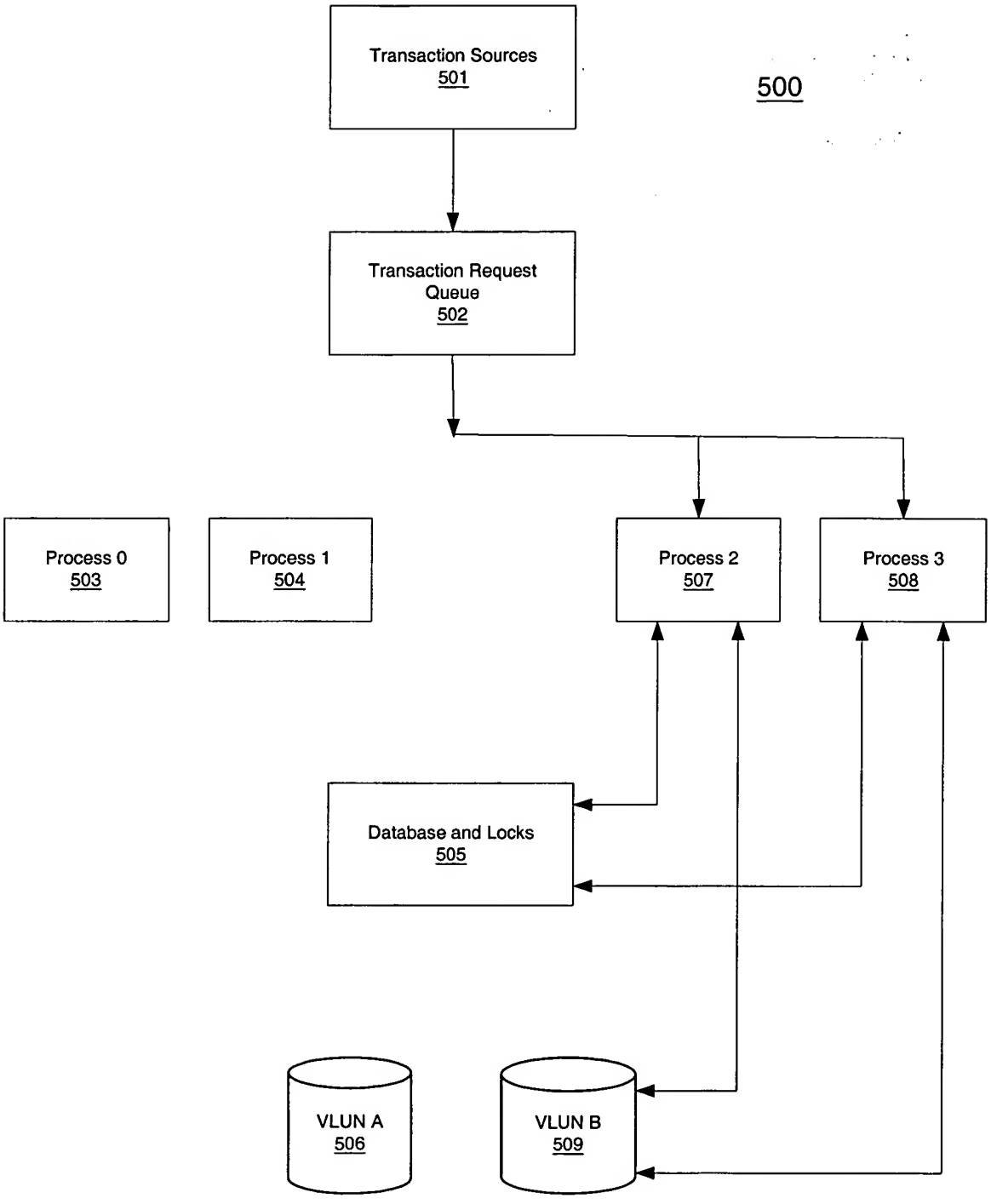

Transaction Sources
501
500
Transaction Request
Queue
502
Process 0
503
Process 1
504
Database and Locks
505
VLUN A
506

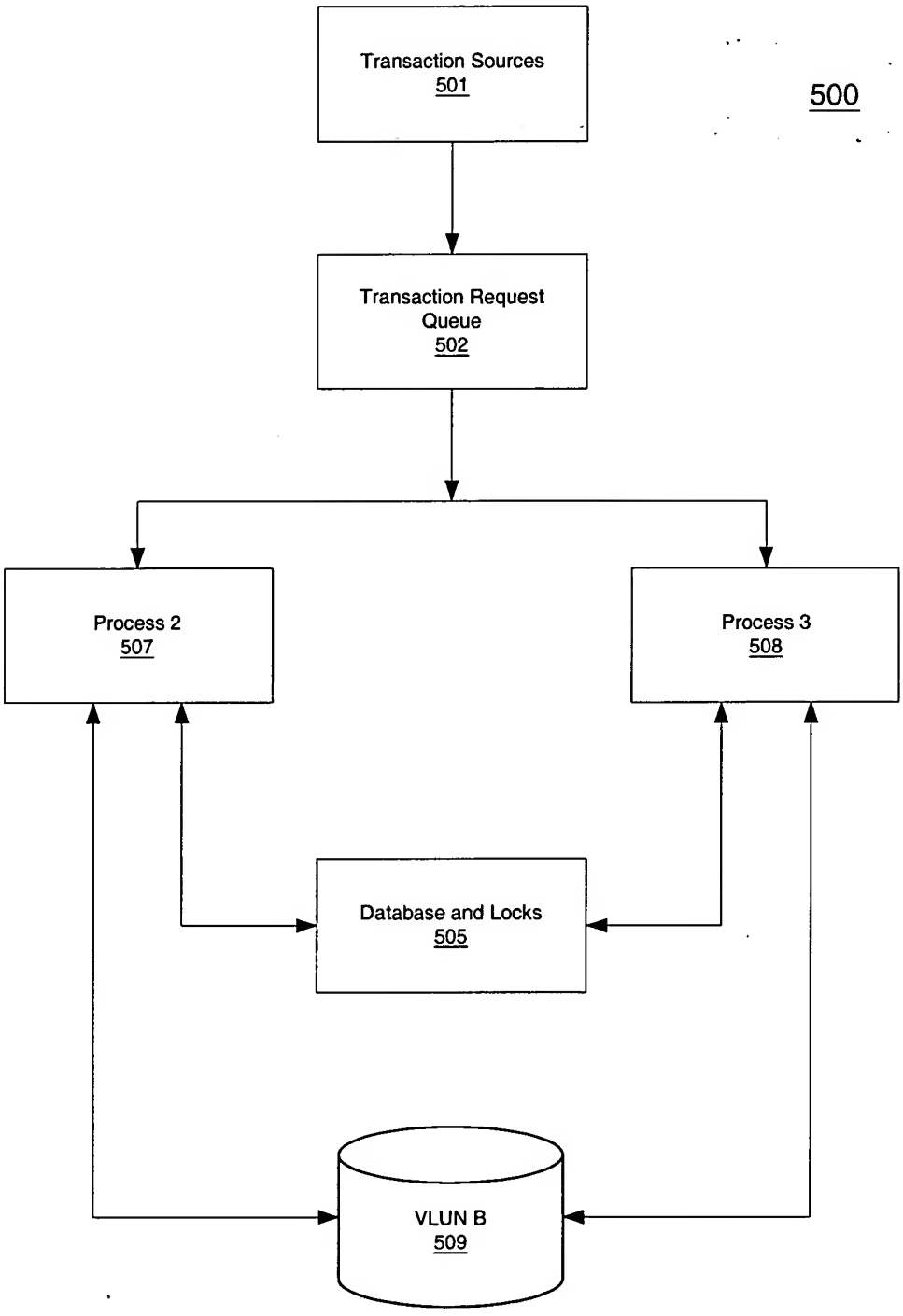
Figure 5A


Transaction Sources
501
500
Transaction Request
Queue
502
Process 0
503
Process 1
504
Process 2
507
Process 3
508
Database and Locks
505
VLUN A
506
VLUN B
509

Figur 5B


Transaction Sources
501
500
Transaction Request
Queue
502
Process 0
503
Process 1
504
Process 2
507
Process 3
508
Database and Locks
505
VLUN A
506
VLUN B
509

Figur 5C


Transaction Sources
501
500
Transaction Request
Queue
502
Process 2
507
Process 3
508
Database and Locks
505
VLUN B
509

Figur 5D

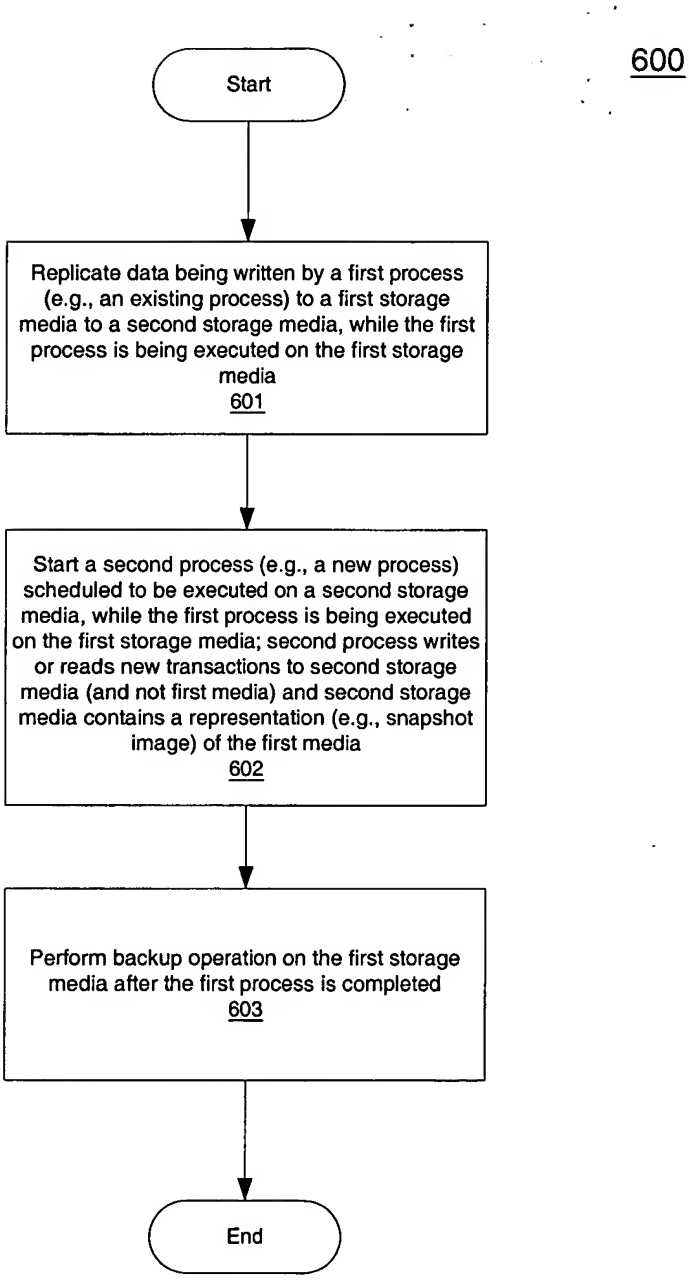
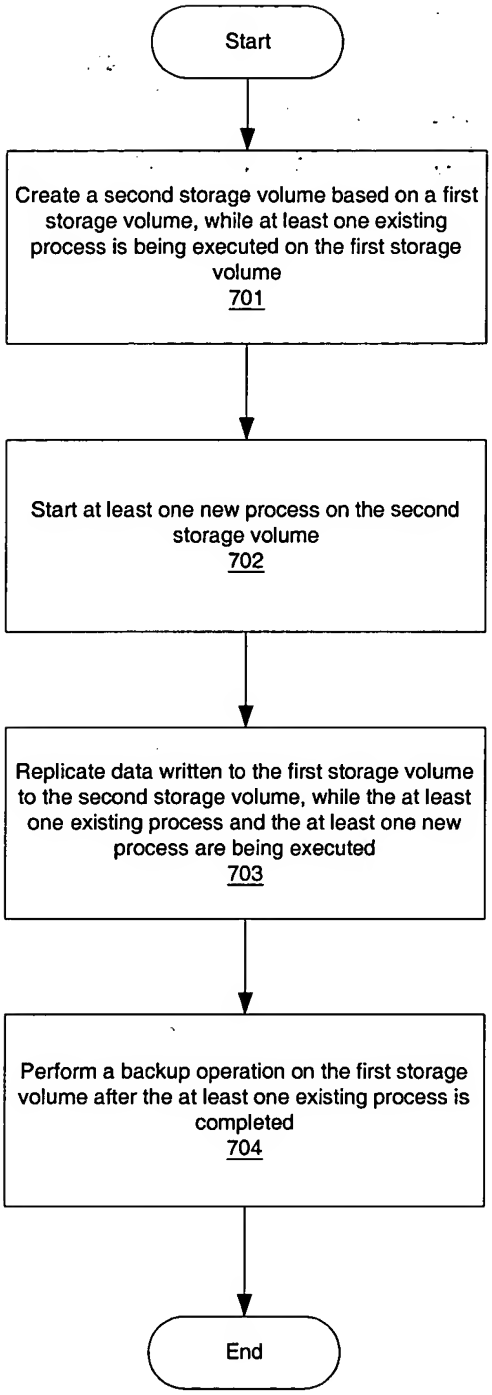

600
Start
Replicate data being written by a first process (e.g., an existing process) to a first storage media to a second storage media, while the first process is being executed on the first storage media
601
Start a second process (e.g., a new process) scheduled to be executed on a second storage media, while the first process is being executed on the first storage media; second process writes or reads new transactions to second storage media (and not first media) and second storage media contains a representation (e.g., snapshot image) of the first media
602
Perform backup operation on the first storage media after the first process is completed
603
End

Figure 6


Start
700
Create a second storage volume based on a first storage volume, while at least one existing process is being executed on the first storage volume
701
Start at least one new process on the second storage volume
702
Replicate data written to the first storage volume to the second storage volume, while the at least one existing process and the at least one new process are being executed
703
Perform a backup operation on the first storage volume after the at least one existing process is completed
704
End

Figur 7

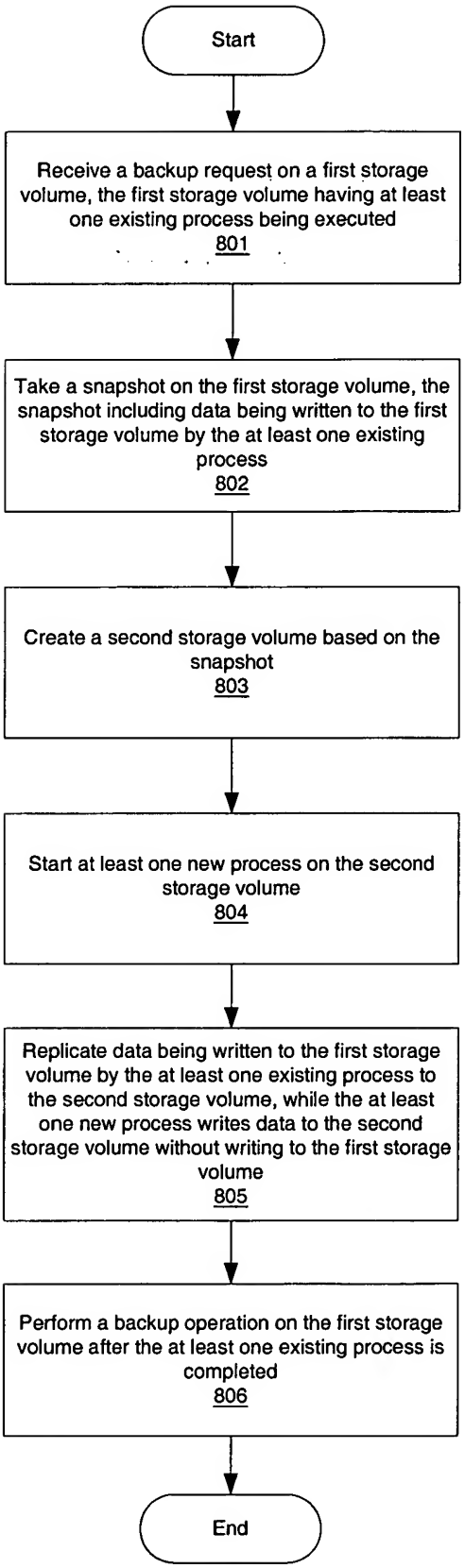

Start
800
Receive a backup request on a first storage volume, the first storage volume having at least one existing process being executed
801
Take a snapshot on the first storage volume, the snapshot including data being written to the first storage volume by the at least one existing process
802
Create a second storage volume based on the snapshot
803
Start at least one new process on the second storage volume
804
Replicate data being written to the first storage volume by the at least one existing process to the second storage volume, while the at least one new process writes data to the second storage volume without writing to the first storage volume
805
Perform a backup operation on the first storage volume after the at least one existing process is completed
806
End

Figure 8

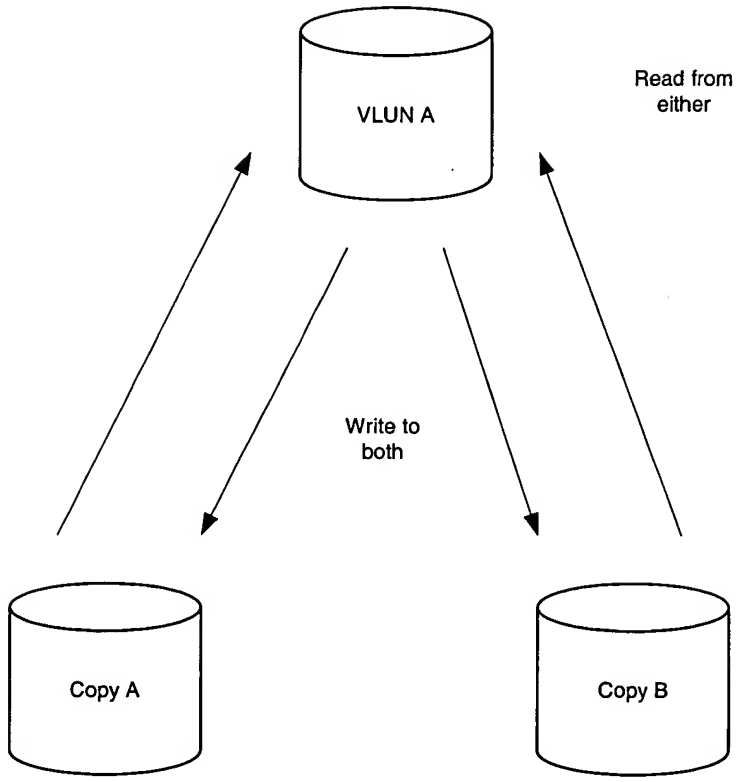


Figure 9A

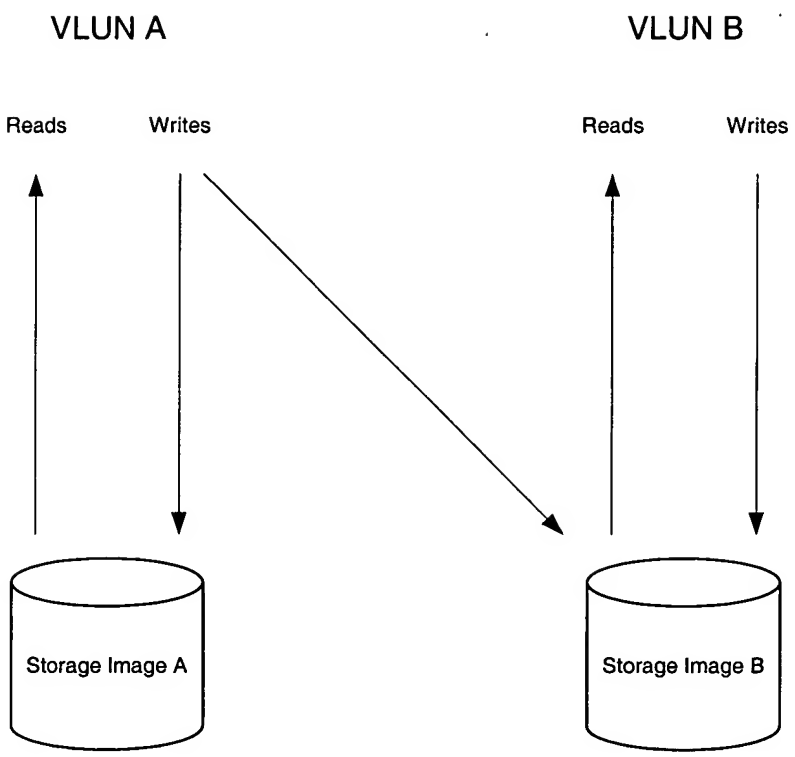

VLUN A
VLUN B
Reads
Writes
Reads
Writes
Storage Image A
Storage Image B

Figure 9B

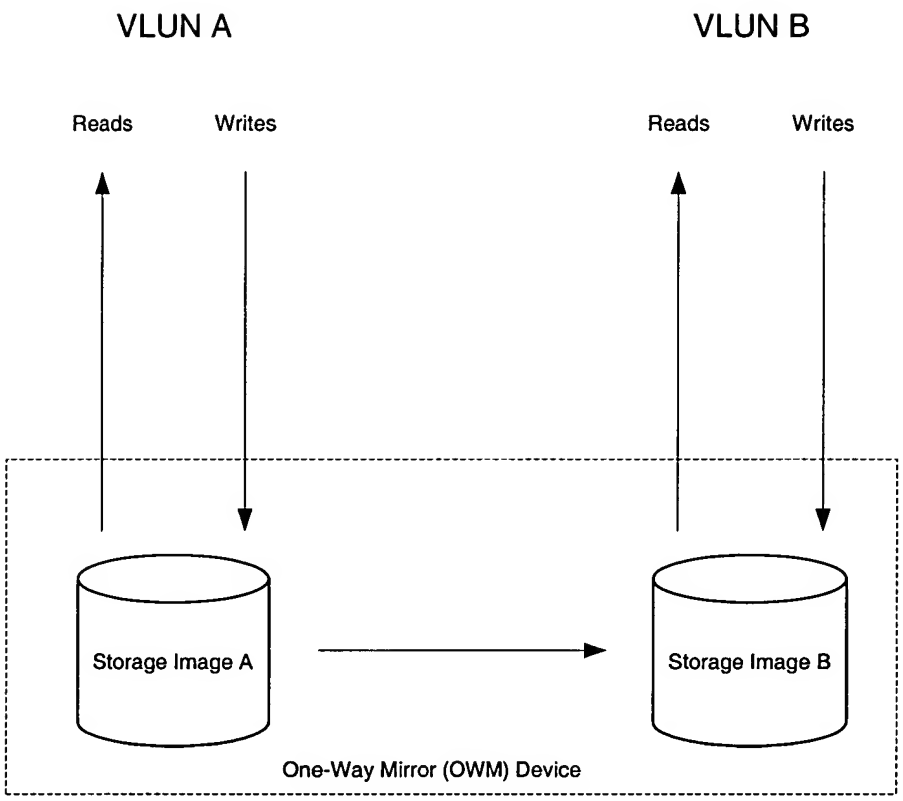

VLUN A
VLUN B
Reads
Writes
Reads
Writes
Storage Image A
Storage Image B
One-Way Mirror (OWM) Device

Figure 10

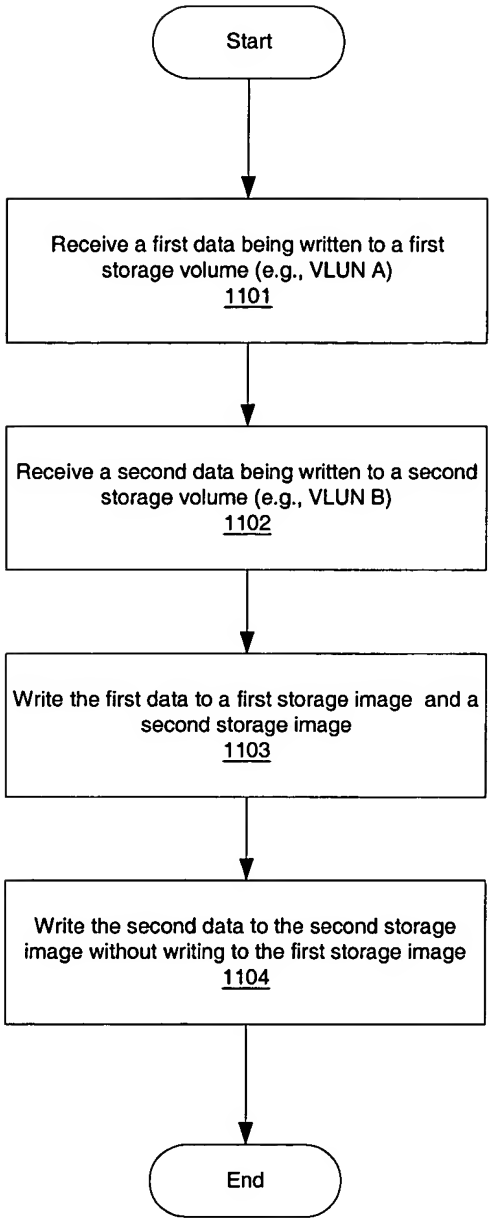

Start
1100
Receive a first data being written to a first storage volume (e.g., VLUN A)
1101
Receive a second data being written to a second storage volume (e.g., VLUN B)
1102
Write the first data to a first storage image and a second storage image
1103
Write the second data to the second storage image without writing to the first storage image
1104
End

Figure 11

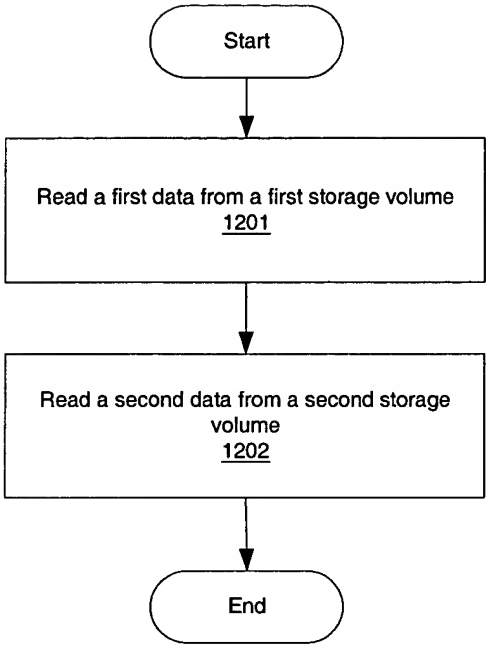
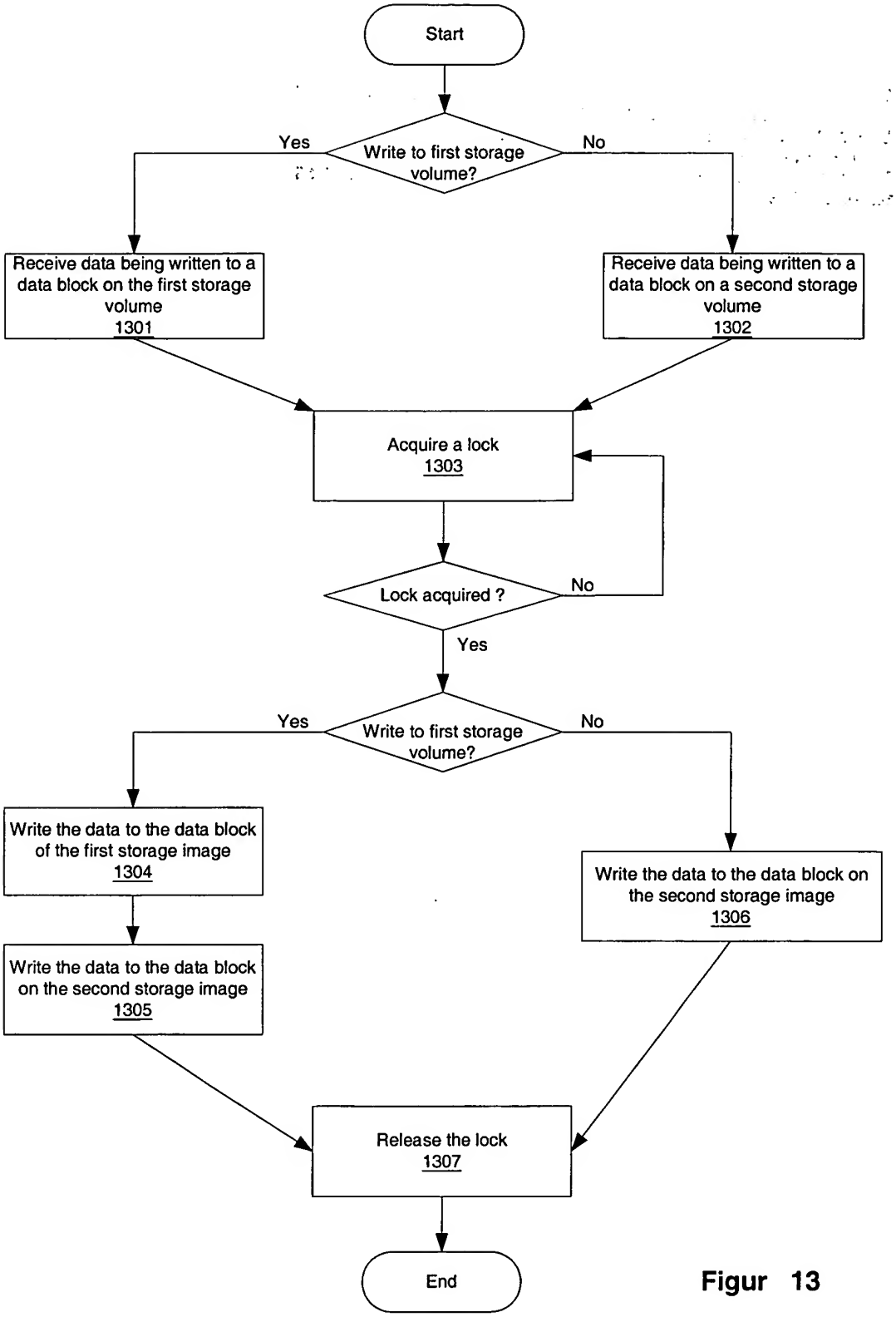

Start
1200
Read a first data from a first storage volume
1201
Read a second data from a second storage volume
1202
End

Figure 12


Start
Write to first storage volume?
Yes
No
Receive data being written to a data block on the first storage volume
1301
Receive data being written to a data block on a second storage volume
1302
Acquire a lock
1303
Lock acquired ?
No
Yes
Write to first storage volume?
Yes
No
Write the data to the data block of the first storage image
1304
Write the data to the data block on the second storage image
1305
Write the data to the data block on the second storage image
1306
Release the lock
1307
End

Figur 13

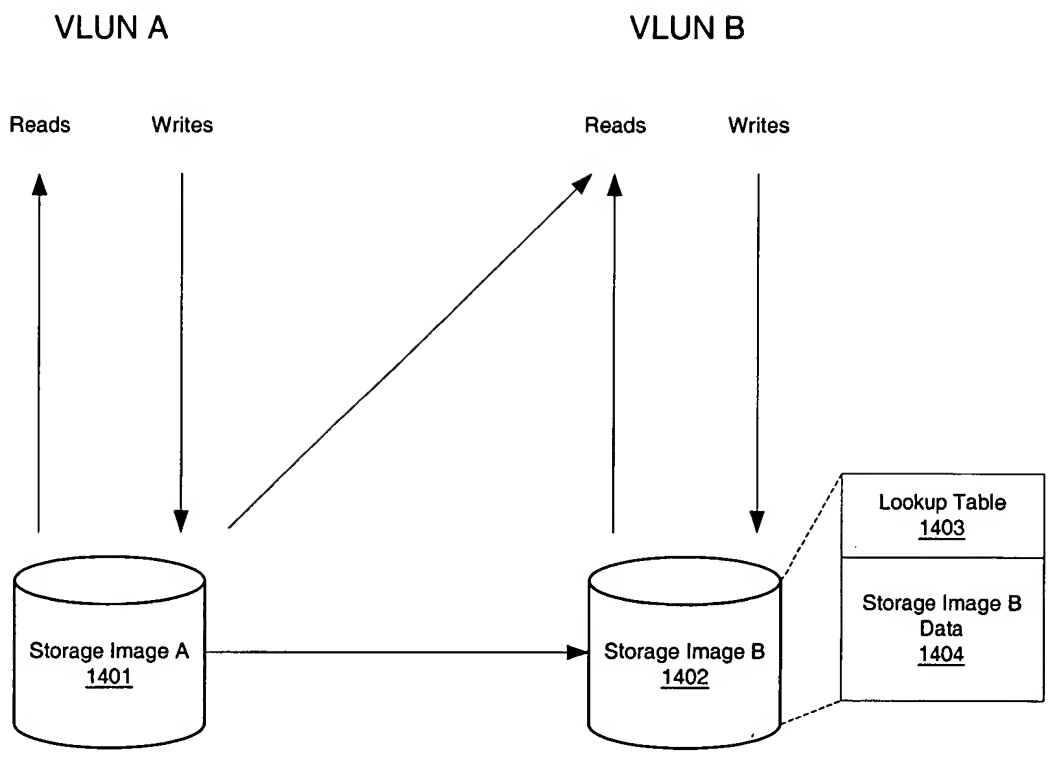

VLUN A
VLUN B
Reads
Writes
Reads
Writes
Lookup Table
1403
Storage Image B
Data
1404
Storage Image A
1401
Storage Image B
1402

Figure 14

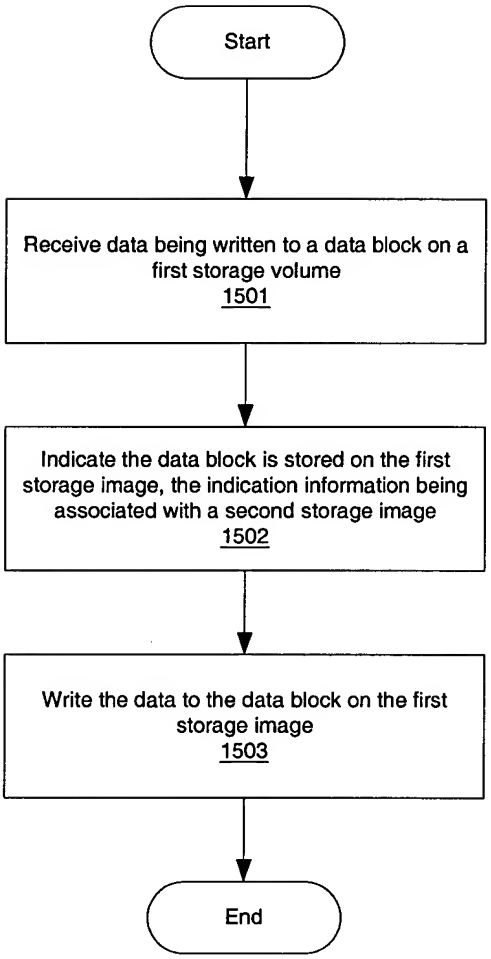

Start
1500
Receive data being written to a data block on a first storage volume
1501
Indicate the data block is stored on the first storage image, the indication information being associated with a second storage image
1502
Write the data to the data block on the first storage image
1503
End

Figure 15

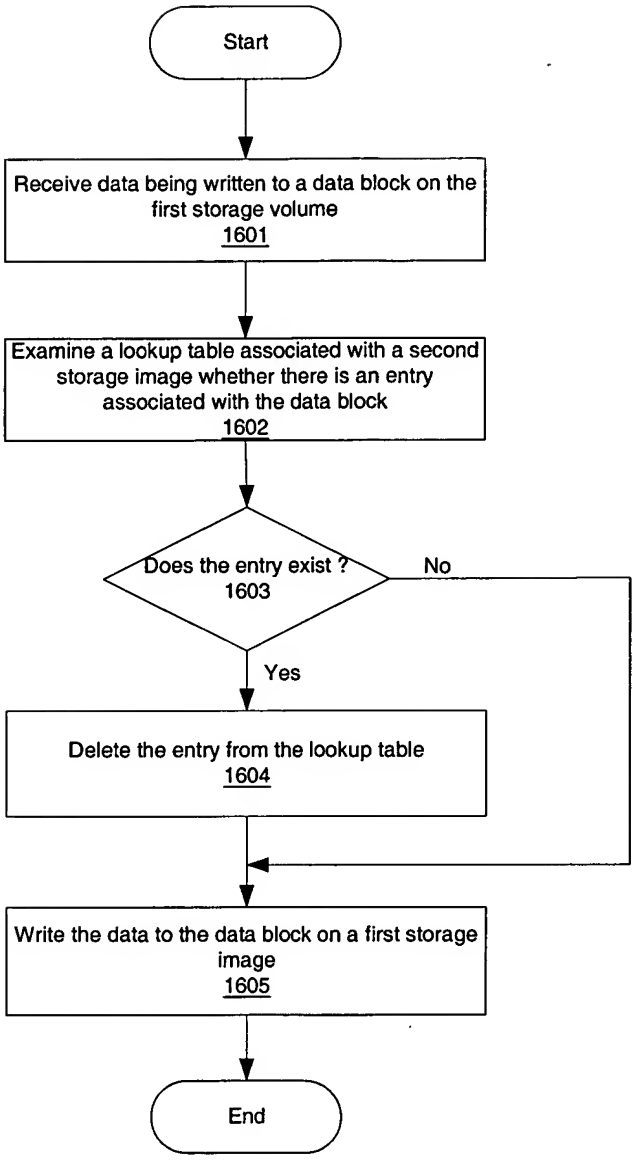

1600
Start
Receive data being written to a data block on the first storage volume
1601
Examine a lookup table associated with a second storage image whether there is an entry associated with the data block
1602
Does the entry exist ?
1603
No
Yes
Delete the entry from the lookup table
1604
Write the data to the data block on a first storage image
1605
End

Figure 16

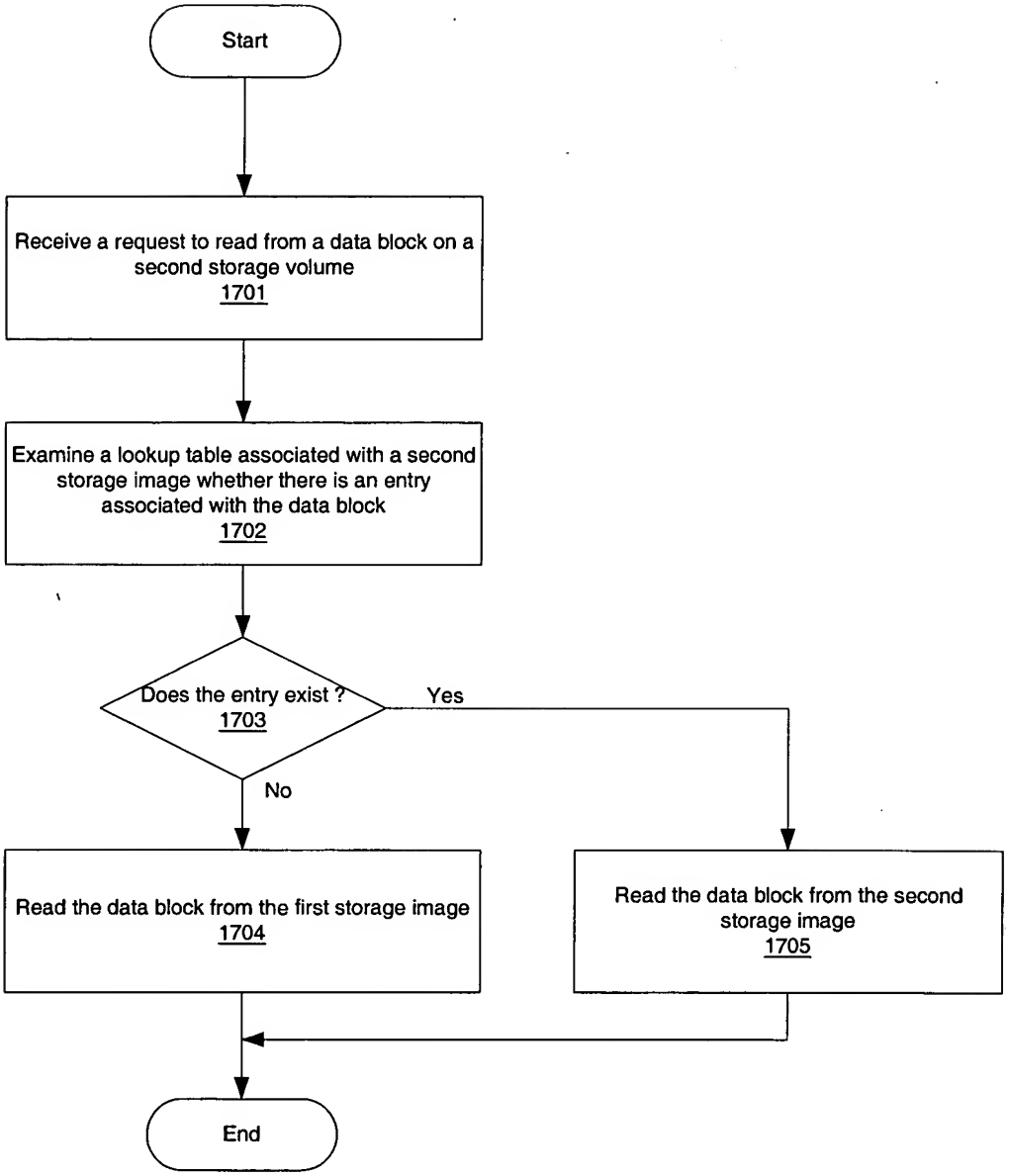

Start
Receive a request to read from a data block on a second storage volume
1701
Examine a lookup table associated with a second storage image whether there is an entry associated with the data block
1702
Does the entry exist ?
1703
Yes
No
Read the data block from the first storage image
1704
Read the data block from the second storage image
1705
End

Figure 17

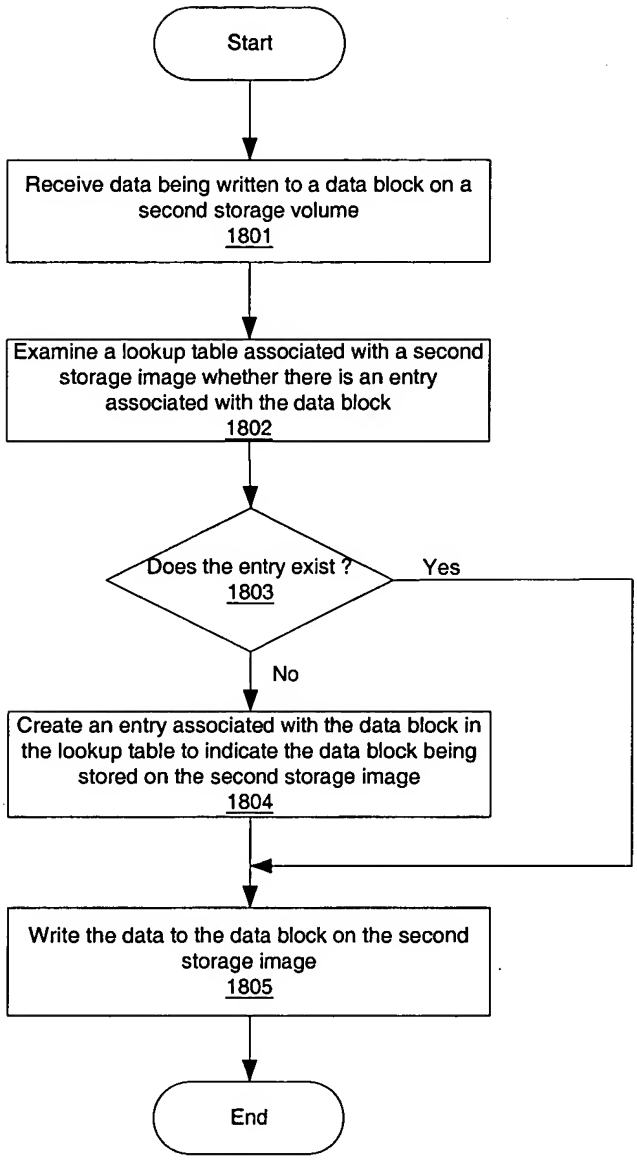
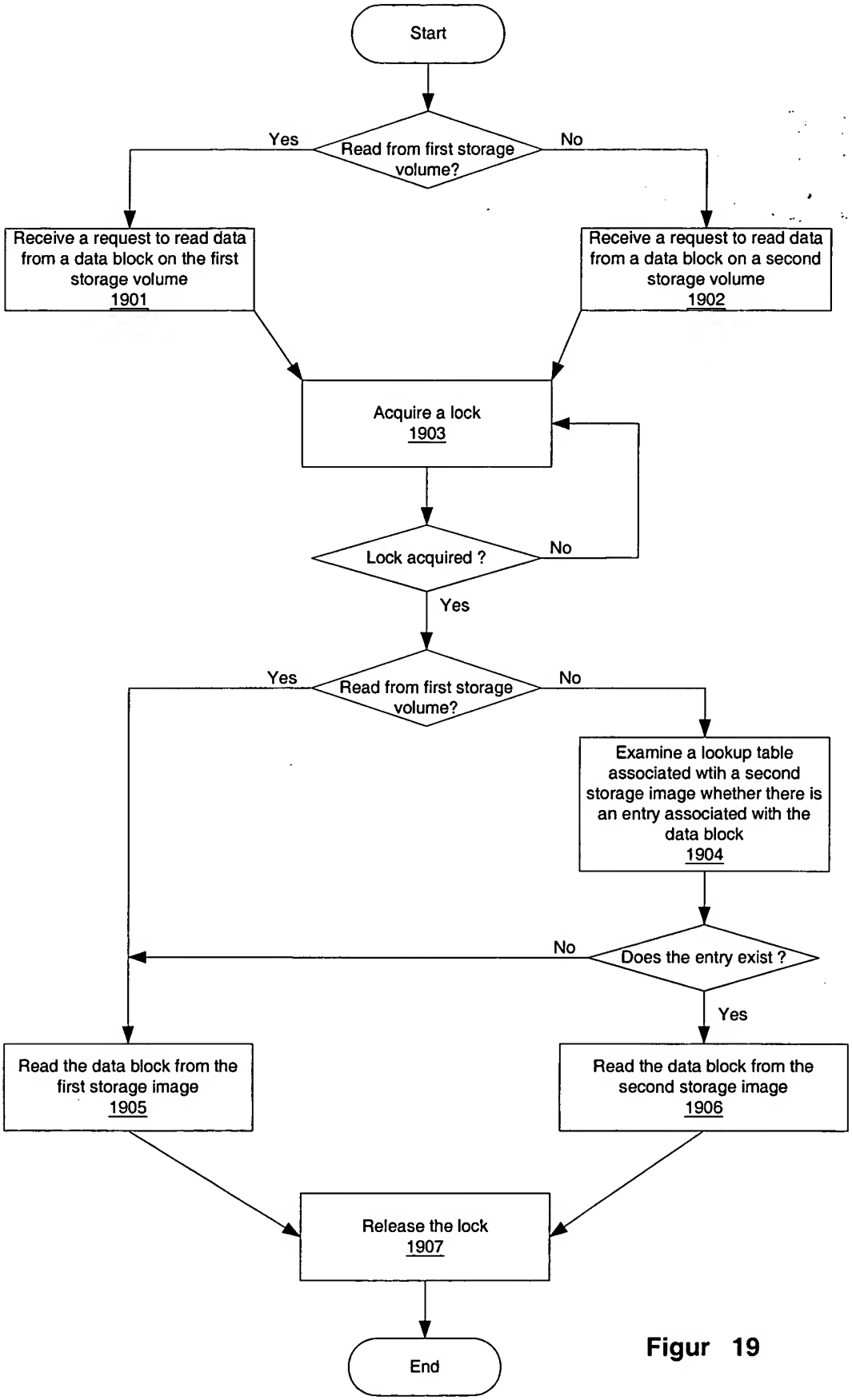
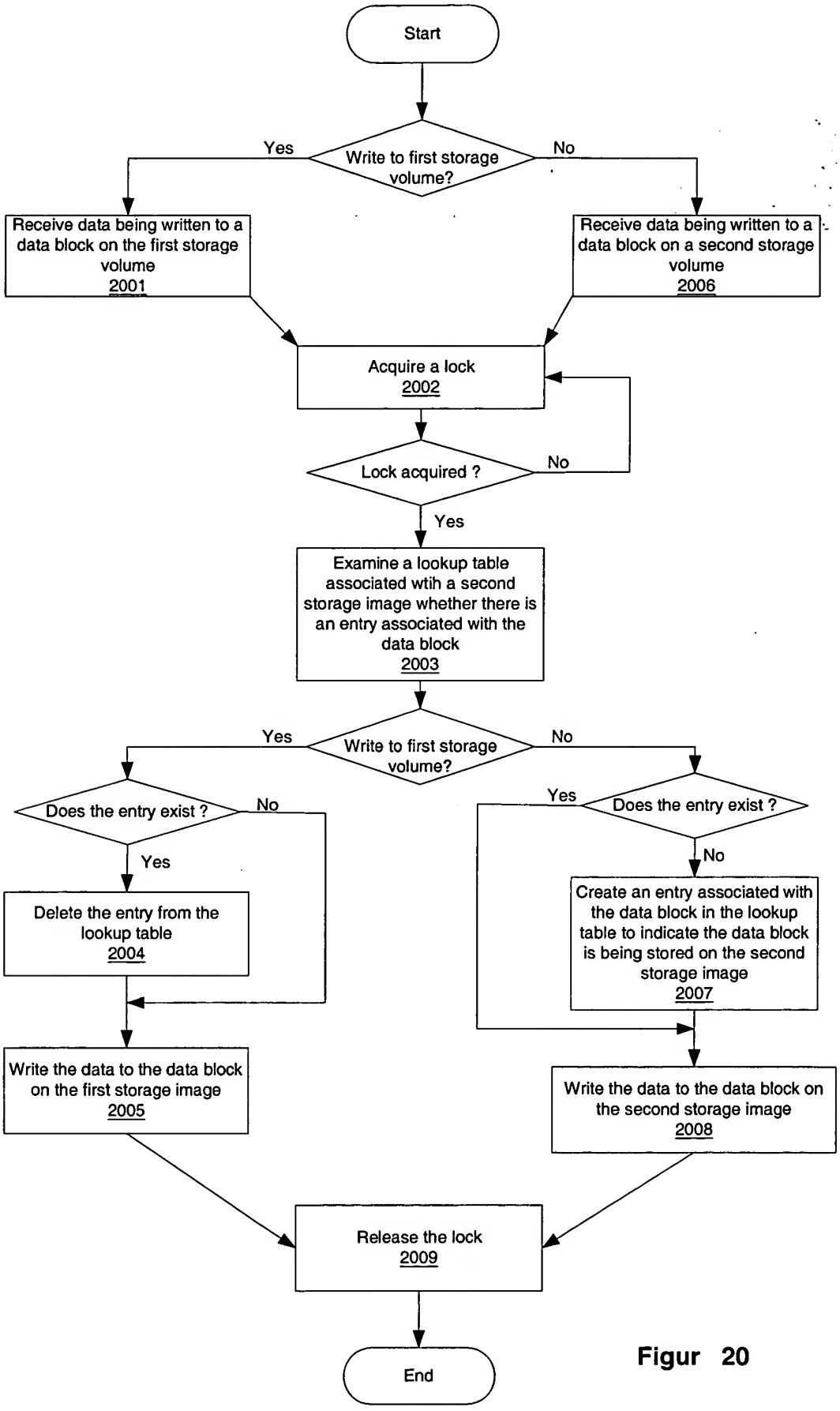

Start
Receive data being written to a data block on a second storage volume
1801
Examine a lookup table associated with a second storage image whether there is an entry associated with the data block
1802
Does the entry exist ?
1803
Yes
No
Create an entry associated with the data block in the lookup table to indicate the data block being stored on the second storage image
1804
Write the data to the data block on the second storage image
1805
End

Figure 18


Start
Read from first storage volume?
Yes
No
Receive a request to read data from a data block on the first storage volume
1901
Receive a request to read data from a data block on a second storage volume
1902
Acquire a lock
1903
Lock acquired ?
No
Yes
Read from first storage volume?
Yes
No
Examine a lookup table associated wtih a second storage image whether there is an entry associated with the data block
1904
Does the entry exist ?
No
Yes
Read the data block from the first storage image
1905
Read the data block from the second storage image
1906
Release the lock
1907
End

Figur 19


Start
Write to first storage volume?
Yes
No
Receive data being written to a data block on the first storage volume
2001
Receive data being written to a data block on a second storage volume
2006
Acquire a lock
2002
Lock acquired ?
No
Yes
Examine a lookup table associated wtih a second storage image whether there is an entry associated with the data block
2003
Write to first storage volume?
Yes
No
Does the entry exist ?
No
Yes
Delete the entry from the lookup table
2004
Write the data to the data block on the first storage image
2005
Does the entry exist ?
Yes
No
Create an entry associated with the data block in the lookup table to indicate the data block is being stored on the second storage image
2007
Write the data to the data block on the second storage image
2008
Release the lock
2009
End

Figur 20

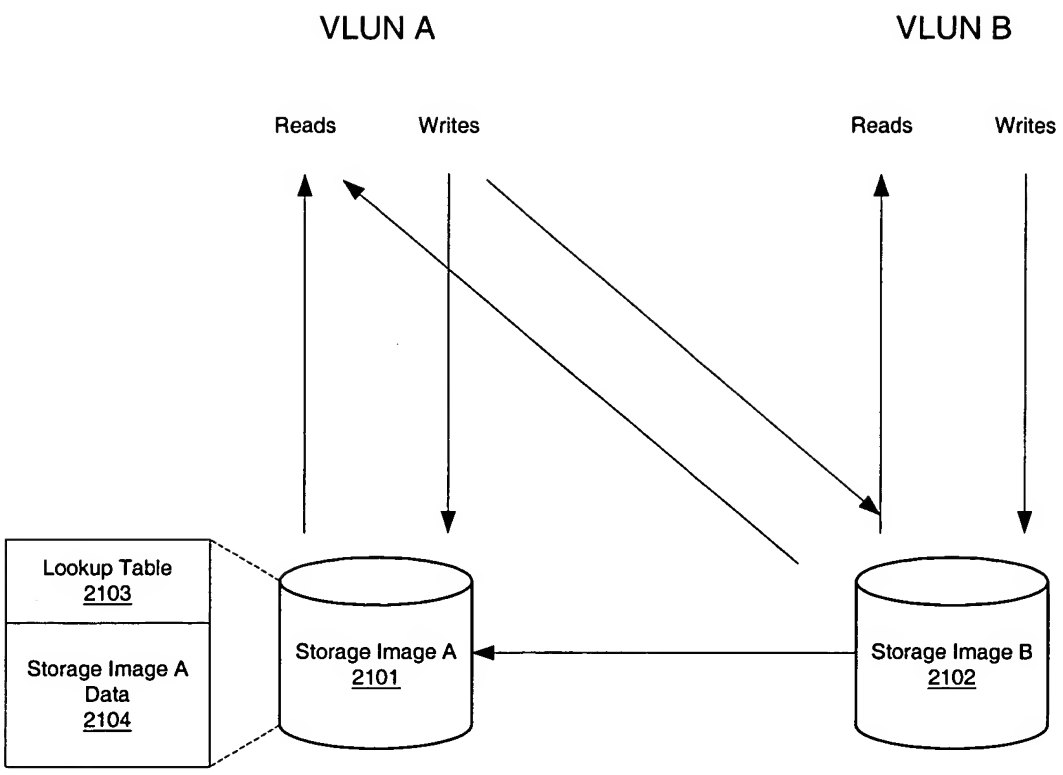

2100
VLUN A
VLUN B
Reads
Writes
Reads
Writes
Lookup Table
2103
Storage Image A
Data
2104
Storage Image A
2101
Storage Image B
2102

Figure 21

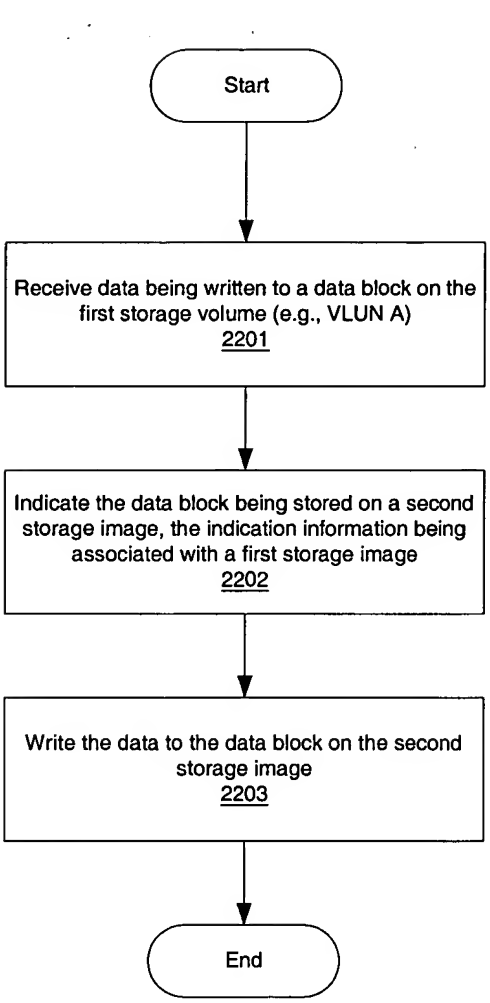

2200
Start
Receive data being written to a data block on the first storage volume (e.g., VLUN A)
2201
Indicate the data block being stored on a second storage image, the indication information being associated with a first storage image
2202
Write the data to the data block on the second storage image
2203
End

Figure 22

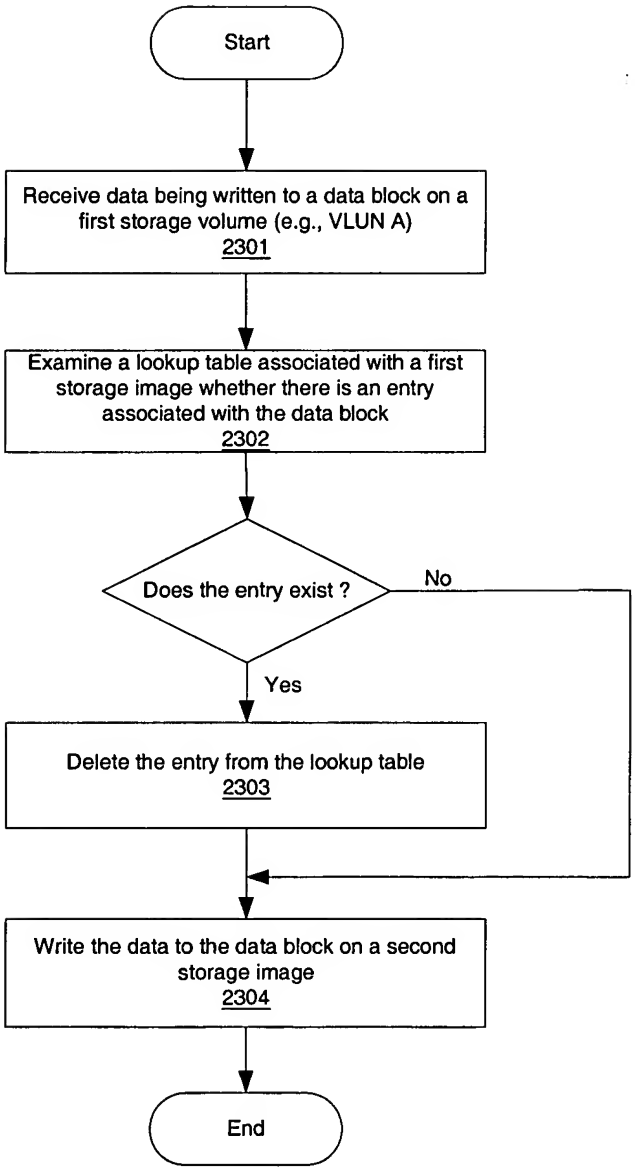

Start
Receive data being written to a data block on a first storage volume (e.g., VLUN A)
2301
Examine a lookup table associated with a first storage image whether there is an entry associated with the data block
2302
Does the entry exist ?
No
Yes
Delete the entry from the lookup table
2303
Write the data to the data block on a second storage image
2304
End

Figure 23

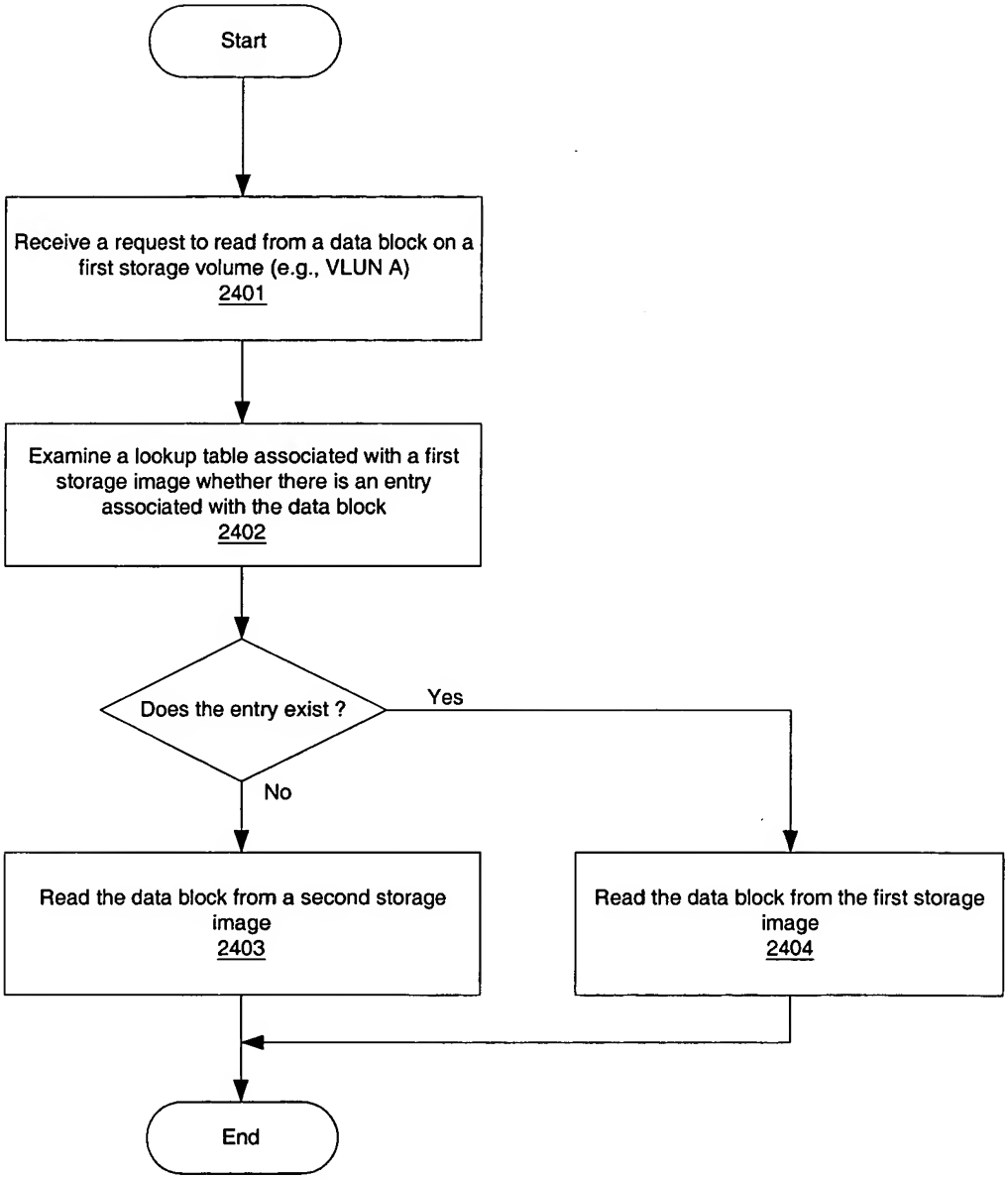

Start
Receive a request to read from a data block on a first storage volume (e.g., VLUN A)
2401
Examine a lookup table associated with a first storage image whether there is an entry associated with the data block
2402
Does the entry exist ?
Yes
No
Read the data block from a second storage image
2403
Read the data block from the first storage image
2404
End

Figure 24

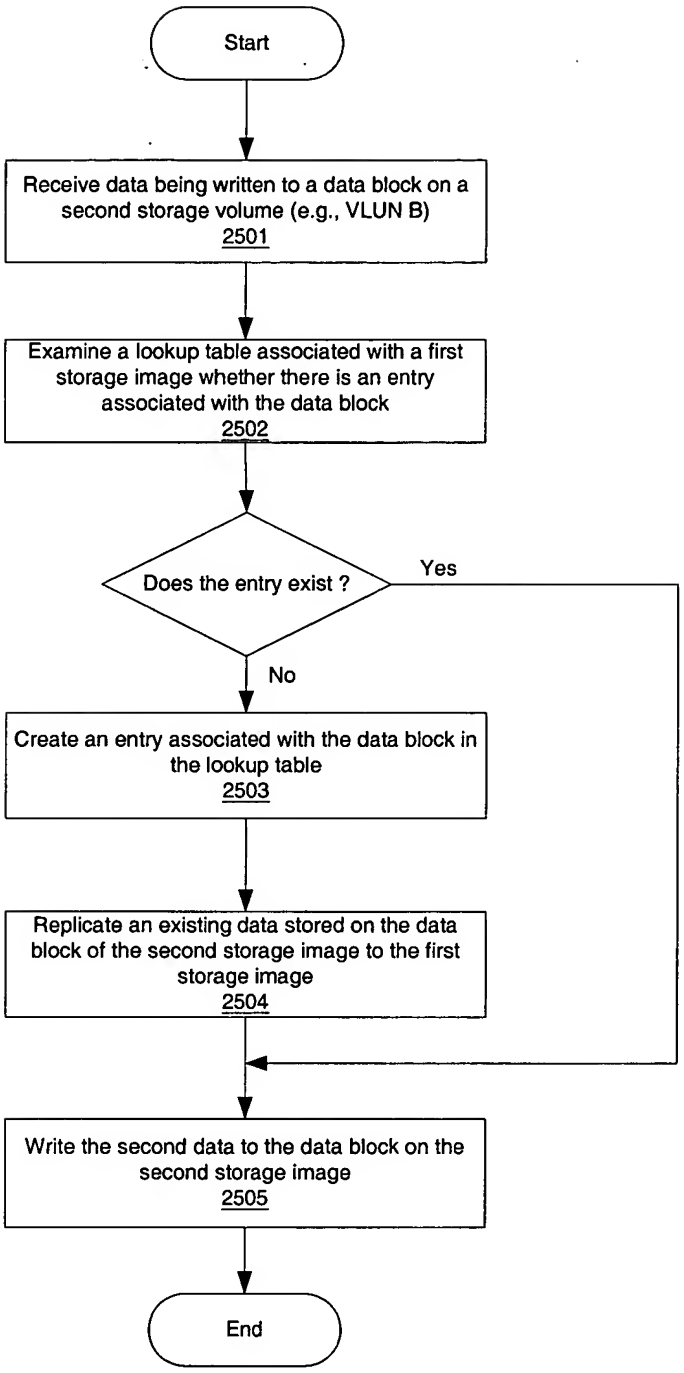
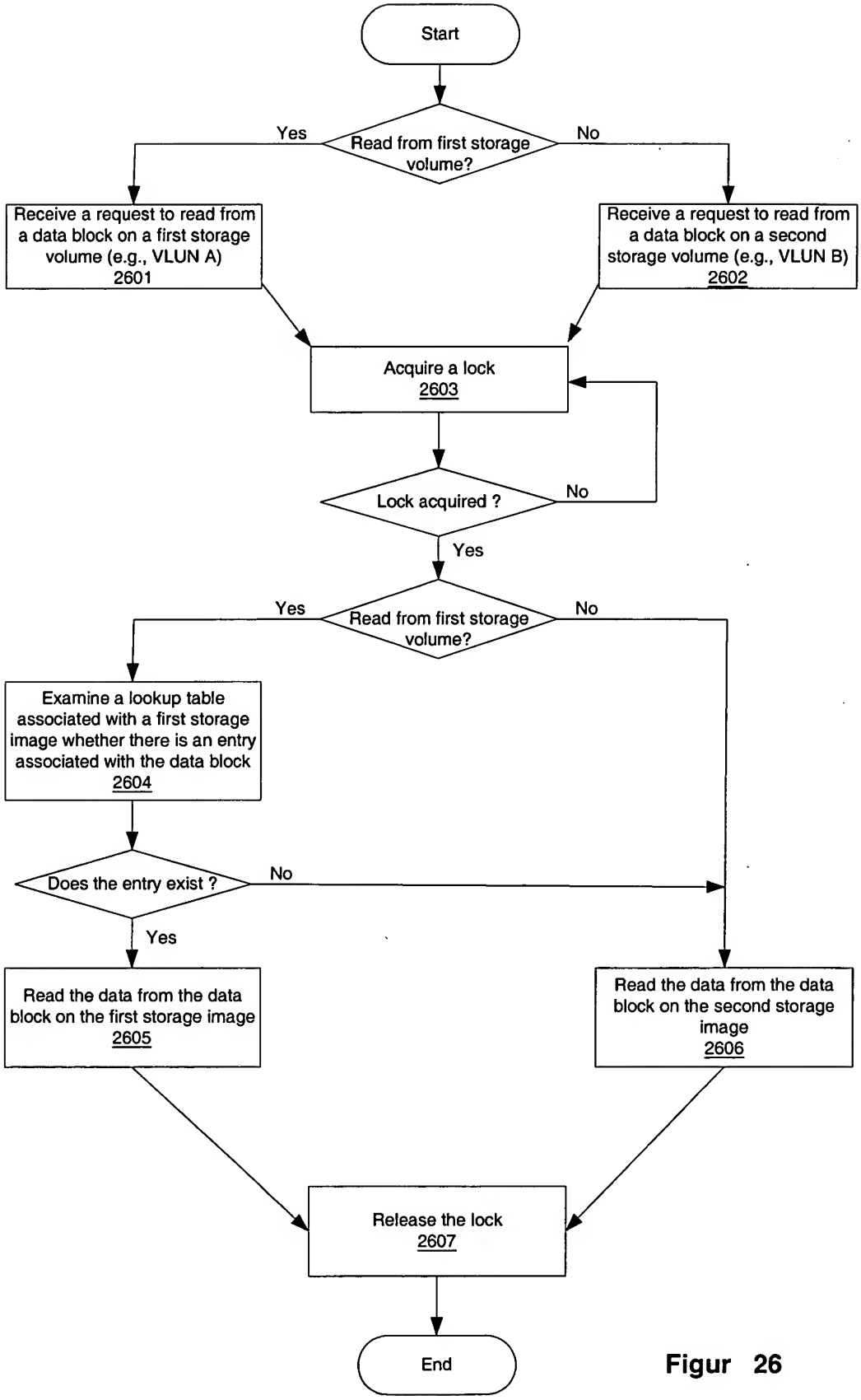
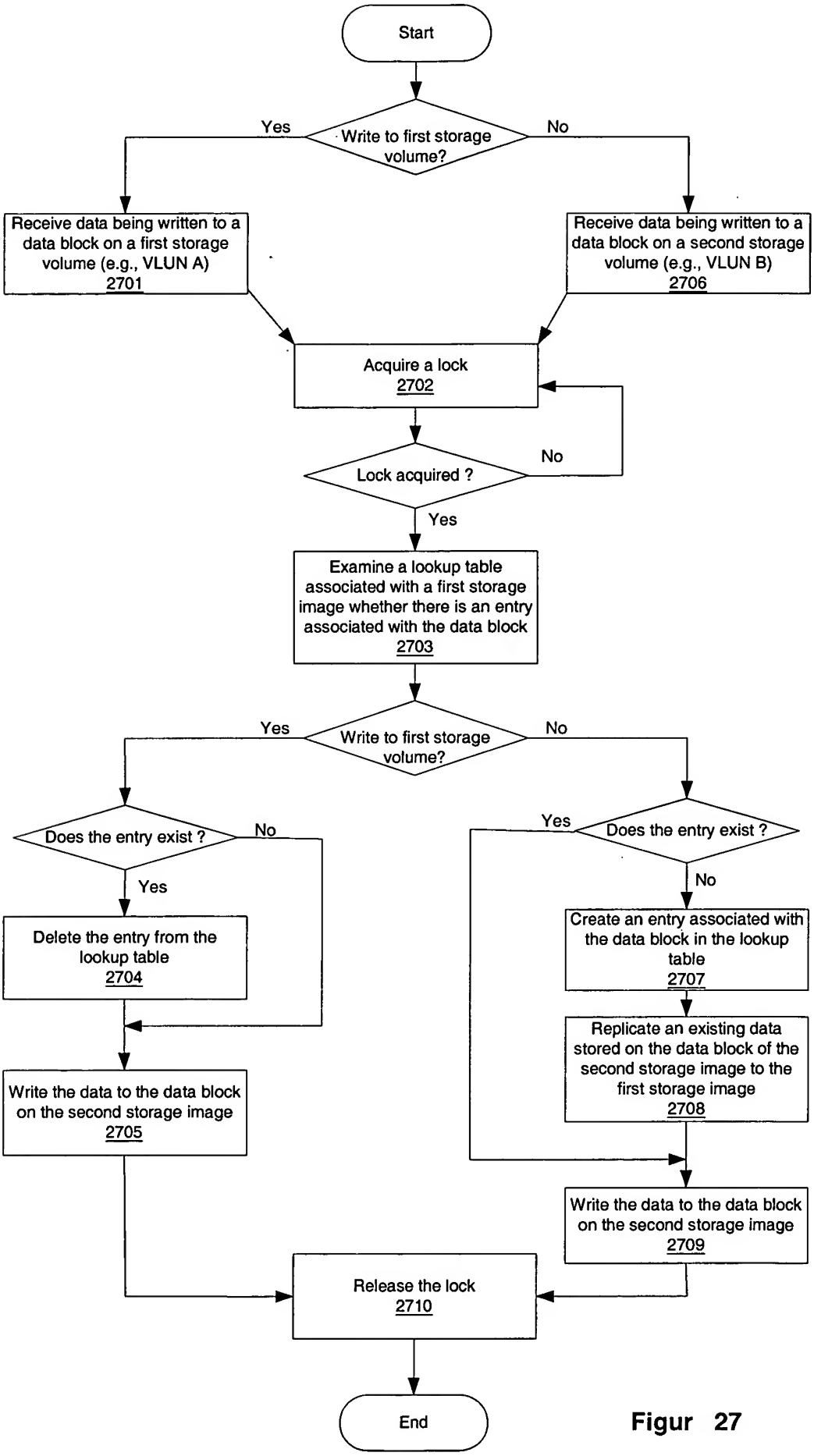

Start
Receive data being written to a data block on a second storage volume (e.g., VLUN B)
2501
Examine a lookup table associated with a first storage image whether there is an entry associated with the data block
2502
Does the entry exist ?
Yes
No
Create an entry associated with the data block in the lookup table
2503
Replicate an existing data stored on the data block of the second storage image to the first storage image
2504
Write the second data to the data block on the second storage image
2505
End

Figure 25


Start
Read from first storage volume?
Yes
No
Receive a request to read from a data block on a first storage volume (e.g., VLUN A) 2601
Receive a request to read from a data block on a second storage volume (e.g., VLUN B) 2602
Acquire a lock 2603
Lock acquired ?
No
Yes
Read from first storage volume?
Yes
No
Examine a lookup table associated with a first storage image whether there is an entry associated with the data block 2604
Does the entry exist ?
No
Yes
Read the data from the data block on the first storage image 2605
Read the data from the data block on the second storage image 2606
Release the lock 2607
End

Figur 26


Start
Write to first storage volume?
Yes
No
Receive data being written to a data block on a first storage volume (e.g., VLUN A) 2701
Receive data being written to a data block on a second storage volume (e.g., VLUN B) 2706
Acquire a lock 2702
Lock acquired ?
No
Yes
Examine a lookup table associated with a first storage image whether there is an entry associated with the data block 2703
Write to first storage volume?
Yes
No
Does the entry exist ?
No
Yes
Delete the entry from the lookup table 2704
Write the data to the data block on the second storage image 2705
Does the entry exist ?
Yes
No
Create an entry associated with the data block in the lookup table 2707
Replicate an existing data stored on the data block of the second storage image to the first storage image 2708
Write the data to the data block on the second storage image 2709
Release the lock 2710
End

Figur 27